

SOY BEAN VERSUS ALFALFA HAY FOR MILK
AND BUTTER FAT PRODUCTION

by

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INTRODUCTION

In certain sections of Kansas where alfalfa cannot be grown economically the soy bean has been found to be a satisfactory substitute because of its drouth-resistant qualities and adaptability as an emergency crop. Alfalfa production in the eastern portion of the state has declined markedly due, in part at least, to insects, plant diseases and unfavorable soil conditions. The soy bean is but little affected by the many conditions which interfere with the growth of alfalfa.

Soy bean hay has been found to compare favorably with alfalfa hay in feeding value for dairy cows in other states and it is possible that it should be used more extensively for dairy herds in Kansas. The experiment herein reported was conducted to obtain some information that would aid in determining the relative value of alfalfa and soy bean hay for milk and butterfat production under Kansas conditions.

The value of soy bean hay as a feed for dairy cows is dependent almost entirely on its quality. Hay from mature plants is coarse and unpalatable and is often refused by cows unless they are forced to eat it. The rate of seeding affects the fineness of the stems. Hay from heavy seeding

is to be preferred to that from thin seeding or from row planting. Investigations have shown that the best quality hay comes from fields sown at the rate of about 60 to 75 pounds of seed per acre and cut at about the time the pods are well formed, but before the seeds are developed much. The amount of hay refused by the animals when fed in ordinary quantities is a measure of its lack of palatability; several investigators having found the amount refused to vary from none to 31.6 per cent.

CITATION OF LITERATURE

Hunsiker and Caldwell (1917, pp. 5-6) compared soy bean hay with alfalfa hay fed with a ration of corn silage, ground corn, and a protein of cottonseed meal, linseed meal or gluten feed. Their results, based on feed consumed rather than feed furnished, showed alfalfa hay to be 12 per cent more valuable than soy bean hay as a milk producing roughage. On soy bean hay the milk production decreased but the fat content increased, resulting in the production of more butter fat.

Anthony and Henderson (1923, p. 10) and Bechdel (1926, p. 15) report soy bean hay slightly superior to alfalfa, but Olson (1925, p. 15), on the other hand found alfalfa more valuable than soy bean hay.

Piper and Morse (1923, p. 109) state that Osborne and Mendel found glycinin, the protein of soy beans to be a complete protein and adequate for promoting normal growth in rats. They also show (1923, pp. 104-105) that soy bean hay is considerably higher in phosphoric acid and magnesium than alfalfa.

Hart and others (1926, pp. 130-131) found that in milk and butter fat production soy bean and alfalfa hay were approximately equal. Because large quantities of the soy bean hay was wasted and because of the body weight lost it was concluded that soy bean hay was 75 per cent as efficient as alfalfa hay.

Schaefer (1927, p. 16) showed that soy beans as a legume hay resulted in a 46 per cent saving of concentrates over timothy hay, and a 93.6 per cent saving in expenditure for mill feed.

Nevens and Tracy (1928, pp. 479-488) report that neither high quality, poor quality or moldy soy bean hay have any effect upon the flavor of milk (raw or pastuerized), skim milk, cream or butter. Ground soy beans were likewise without affect on flavor but affected the body of the butter. Ground soy beans caused the body of the butter to be gummy, soy bean hay had a similar affect but to a less degree.

Morrow and LaMaster (1929, p. 28) concludes that grinding increases the palatability of soy bean hay. Grinding did not increase the digestibility of the nutrients of the hay, but due to the increase in the amount consumed it was found to be profitable.

EXPERIMENTAL PLAN

Object of the Experiment

The object of this feeding trial was to compare the relative value of soy bean and alfalfa hay for milk and butter fat production.

Cows Used

Ten cows, six Ayrshires, two Holsteins and two Holsteins and two Guernseys, were selected from the college herd for use in the experiment. They were divided into two groups as evenly as possible; the division being based on stage of lactation, stage of gestation, milk produced daily, body weight, age, per cent of butter fat and previous production.

Table II gives in detail a description of these cows at the beginning of the experiment. It will be noted that the division was fairly even with the exception of the age

factor. Other factors changed somewhat as the experiment progressed, but as a whole the balance was well maintained throughout the project. No abnormal situations, such as sickness or injury, occurred to any of the animals.

Duration

The experiment was conducted for 90 days, from October 2, 1928, to December 31, 1928 inclusive. The time was divided into three 30-day periods, the first 10 days of each being considered preliminary and not included in the experimental results.

Method of Feeding and Watering

The cows stood in ordinary stanchions and were fed each morning and evening in regular experimental feeding mangers. All feeds were weighed to each individual and refused material was weighed back and deducted from the total.

The stalls were equipped with individual drinking cups which supplied each cow with an abundance of clean, fresh water.

Housing and Exercise

The cows were housed in the northwest corner of the

college dairy barn in regulation stalls. As much as the weather would permit the cows were allowed to exercise in a dry lot. The cows were out during the day approximately two-thirds of the 90 day period.

Body Weights of Cows

The cows were weighed on the first three and the last three days of each experimental feeding period. The weights were taken between 8 and 9 o'clock a. m. each time. The average of the last three weights of each animal was considered the true weight of the animal for the period, the average of the first weights being used for comparative purposes only.

Milk Weights and Per Cent Butter Fat

Daily milk weights were kept for each individual cow. The cows were hand milked twice daily at twelve hour intervals by the same milker.

The per cent butter fat was determined by taking the average test of representative samples of six milkings from the exact middle of each experimental period from each individual cow.

Composition of Feeds

Composite samples of feed were analyzed in the feed analysis laboratory of the Kansas Agricultural Experiment Station once each experimental period. Samples of the hay and grain mixture were made up at the time of grinding and mixing and a representative portion used. The silage samples were taken directly from the silo. One extra sample of soy bean hay was analyzed during the second period for moisture.

Determination of Digestible Nutrients

The digestible matter of any feed constituent was determined by multiplying the per cent composition of that constituent by its coefficient of digestibility reported by Henry and Morrison (1923, App., Table II).

Feeds Used

Soy bean hay from seed planted in rows five inches apart was used. The A. K. variety of soy bean was used and the hay was cured under favorable conditions on the college dairy farm. Although the hay was cut just as the beans began to develop and was quite heavily leaved, it

was high in fiber and low in crude protein. (See Table V.)

According to chemical analysis it would appear that the soy bean hay should compare very favorably to the alfalfa hay in feeding value. The pounds of digestible nutrients contained in the two hays, according to Henry and Morrison's (1923, p. 736) digestibility table is shown in Table I.

Table I. -- Average Number of Pounds of Digestible Nutrients in 100 Pounds of Hay.

Hay	Digestible Nutrients					
	Dry Matter	Crude Protein	Carbo-hydrate	Fat	Total	
	pounds	pounds	pounds	pounds	pounds	pounds
Alfalfa	91.1	10.2	17.1	.08	49.1	
Soy bean	91.4	11.7	39.2	1.2	53.6	

The alfalfa hay used was of average quality being slightly high in crude fiber and having about 14 per cent crude protein. The grain mixture was composed of four parts yellow corn, two parts of wheat bran and one part of linseed oil meal. Atlas Sorgo silage was used. The silage contained approximately 0.1 per cent more digestible crude protein and 4 per cent more total digestible nutri-

ents than the average sorghum silage as quoted by Henry and Morrison (1923, App., Table III).

Rations Fed

All of the cows received the basal ration of sorghum silage and the 4-2-1 grain mixture. Group I, consisting of five cows, received alfalfa hay during the first and third periods and soy bean during the second period. Group II, consisting of five cows, was fed soy bean hay during the first and third periods and alfalfa hay during the second period.

Method of Computing Rations

The nutrient requirements for the first feeding period were determined by using the average body weights taken the first three days of the preliminary period, the average butter fat test of the month previous, and the average milk production for the ten days previous to the beginning of the experiment. For the second and third periods the average milk production for the last five days of the previous periods, the average test of the previous period and the average body weight of the last three days of the previous period were used to determine the nutrient requirements. The rations were computed according to the requirements in-

dicated in the Henry and Morrison feeding standard. The maximum amount of digestible crude protein and the minimum amount of total digestible nutrients were used in order to feed as much hay as possible.

EXPERIMENTAL RESULTS

Feed Consumed

As seen in Table X the five cows in Group I, while being fed alfalfa hay during Periods I and III, consumed an average of 3,010 pounds of silage, 770 pounds of grain and 980 pounds of hay. The average digestible crude protein fed during Periods I and III was 205.33 pounds and the average total digestible nutrients 1,656.91 pounds. During Period II they consumed 2,500 pounds of silage, 960 pounds of grain and 1,240 pounds of hay containing 204.79 pounds of digestible crude protein and 1,599.48 pounds of total digestible nutrients. This shows a difference of .54 pounds of digestible crude protein and 56.43 pounds of total digestible nutrients in favor of the soy bean period.

Group II consumed an average of 2,470 pounds of silage, 780 pounds of grain and 1,130 pounds of soy bean hay during Periods I and III. The average digestible crude protein fed during Periods I and III was 184.99 pounds and the

average total digestible nutrients 1,626.95 pounds. During Period II they consumed 2,620 pounds of silage, 760 pounds of grain and 980 pounds of hay containing 175.96 pounds of digestible crude protein and 1,466 pounds of total digestible nutrients. This shows that Group II when on soy bean hay consumed on the average 9.03 pounds of digestible crude protein and 160.95 pounds of total digestible nutrients more than when on alfalfa hay.

Body Weights of Cows

Table III gives a summary of the weights for the cows individually and as groups. The total average gain in weight of Group I on alfalfa hay was 8.3 pounds per cow. Their gain in weight on soy bean hay was 2.4 pounds per cow or a difference of 5.8 pounds per cow in favor of alfalfa hay.

Group II, according to Table III, made an average gain in weight on soy bean hay of 10.4 pounds per cow. Their gain in weight on alfalfa hay was 4 pounds per cow or a difference of 6.4 pounds per cow in favor of soy bean hay.

Milk and Butter Fat Produced

Table X gives the milk and butter fat production for the two groups. Group I produced an average of 2,176.7

pounds of milk and 86.94 pounds of butter fat during Periods I and III. During Period II on soy bean hay Group I produced 2,044 pounds of milk and 85.02 pounds of butter fat, making a difference of 132.7 pounds of milk and 2.22 pounds of butter fat in favor of alfalfa hay. These results are shown graphically in Figure I. The average fat test of the milk of Group I was 4.08 per cent while on alfalfa hay and 4.27 while on soy bean hay.

Group II produced an average of 2,274.5 pounds of milk and 85.82 pounds of butter fat during Periods I and III. During Period II on alfalfa hay Group II produced 2,262.2 pounds of milk and 86.18 pounds of butter fat, making a difference of 12.3 pounds of milk in favor of soy bean hay and 2.88 pounds of fat in favor of alfalfa hay. Figure I also shows these results graphically. The average fat test of the milk of Group II was 3.85 while on soy bean hay and 3.96 while on alfalfa hay. Table IX is a summary of the milk and butter fat production and the body weights of the individual cows.

Nutrients Consumed per Unit Production

The efficiency of soy bean hay as compared to alfalfa hay is shown in Table XI. The nutrients consumed per unit

of production was used as a basis of comparison because of the wide variation in the composition of the feeding stuffs. With Group I soy bean hay ration was 94.20 per cent as efficient a source of total digestible nutrients in producing 100 pounds of milk as was alfalfa hay. With Group II it was 95.56 per cent as efficient a source of protein and 90.63 per cent as efficient a source of total digestible nutrients in producing 100 pounds of milk as was alfalfa hay.

In producing a pound of butter fat the protein content of soy bean hay was 97.91 per cent as efficient and the total digestible nutrients was 101.04 per cent as efficient as alfalfa hay with Group I. With Group II in producing a pound of butter fat the protein content of soy bean hay was 92.55 per cent as efficient and the total digestible nutrients was 87.81 per cent as efficient as alfalfa hay.

Per Cent Butter Fat in Milk

Contrary to other investigations this experiment did not indicate that soy bean hay tends to increase, for a short period at least, the per cent of butter fat in milk. From the total pounds of milk and butter fat produced the true average butter fat test of the milk was calculated. It was found that the average fat test on soy bean hay was 3.889 per cent and the average butter fat test on alfalfa

was 3.961 per cent, making the slight difference of 0.072 per cent in favor of alfalfa hay.

EXPERIMENTAL NOTES

The experiment progressed very smoothly throughout its entire course. All of the cows maintained their health and appetites and no abnormal conditions developed. However, one cow, No. 151, decreased in milk flow more rapidly than any of the others. This tended to unbalance the experiment somewhat.

CONCLUSIONS

1. Alfalfa hay produced 0.34 per cent more milk and 1.60 per cent more butter fat than did soy bean hay, while soy bean hay produced 1.10 per cent more gain in body weight.
2. Slightly more digestible nutrients were required per unit of product when soy bean hay was fed.
3. Neither hay was more valuable than the other in maintaining body weights of the cows. Group I made a gain in weight of 5.8 pounds per cow in favor of alfalfa hay and Group II made a gain in weight of 6.4 pounds per cow in favor of soy bean hay.
4. Soy bean hay did not increase the per cent fat in

milk over a short period of time. The per cent butter fat in milk was 0.072 greater when alfalfa hay was fed.

5. The soy bean hay used in this experiment was high in fiber and low in crude protein. It might be concluded that soy bean hay of good quality is equal to alfalfa hay for milk and butter fat production.

ACKNOWLEDGMENT

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Table II. -- Descriptive Summary of Cows Used

Cow No.	Breed	Age	Weight	Lactation	Days in gestation	Days in Par	Pounds of milk	Percent coefficient of variation
Group I								
151	Holstein	6	1341	7	39	Open	43.5	3.1:5.19
257	Ayrshire	6	7	1227	190	101	21.7	3.7:5.12
276	Ayrshire	3	8	942	29	Open	30.4	4.3:4.98
427	Guernsey	8	11	962	143	Open	20.3	4.6:4.92
291	Ayrshire	2	6	898	35	Open	25.4	3.1:4.79
Average:	5	7	1080	87	20	28.3	3.1:5.00
Group II								
179	Holstein	2	5	1090	54	Open	25.5	3.2:2.60
284	Ayrshire	3	0	1042	151	Open	24.8	3.4:5.40
287	Ayrshire	2	9	1057	28	Open	29.0	3.9:4.95
446	Guernsey	7	1	822	173	Open	24.5	4.6:4.92
272	Ayrshire	4	5	1060	38	Open	34.2	3.9:4.95
Average:	3	9	1025	81	0	27.5	3.1:4.56

Table III. -- Weights of Cows

Cow No.	Period I (Alfalfa)		Period II (Soy bean)		Period III (Alfalfa)	
	Weight at be- ginning	Weight at end	Weight at be- ginning	Weight at end	Weight at be- ginning	Weight at end

Group I

	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
151	1357	1369	1357	1371	1344	1322
257	1233	1243	1234	1247	1227	1270
276	957	989	975	981	987	971
427	976	978	987	964	964	982
291	906	907	917	919	907	910
Total	5429	5486	5470	5482	5429	5455

Group II

	(Soy bean)	(Alfalfa)	(Soy bean)
179	1066	1091	1074
284	1035	1028	1007
287	1056	1080	1045
446	820	851	819
272	1041	1070	1041
Total	5018	5120	4980

Table IV. -- Summary of Feeds and Digestible Nutrients Consumed.

Feed	Pounds	DCP*	TDN**	Feed	Pounds	DCP*	TDN**
Group I							
Period I							
Silage : 2920.0 : 20.44 : 592.76 : Silage : 2000.0 : 14.00 : 406.00 Grain : 840.0 : 95.34 : 623.92 : Grain : 820.0 : 93.06 : 606.60 Hay : : : : Hay : : : (alf.) : <u>1098.0</u> : <u>106.45</u> : <u>553.72</u> : (soy) : <u>1281.0</u> : <u>91.33</u> : <u>684.60</u> Total : ---- : 222.23 : 1770.4 : Total : ---- : 198.39 : 1697.2							
Period II							
Silage : 2500.0 : 17.50 : 505.90 : Silage : 2620.0 : 18.34 : 531.86 Grain : 860.0 : 97.02 : 638.86 : Grain : 760.0 : 86.26 : 562.54 Hay : : : : Hay : : : (soy) : <u>1222.0</u> : <u>89.17</u> : <u>652.12</u> : (alf.) : <u>980.0</u> : <u>96.62</u> : <u>493.32</u> Total : ---- : 203.69 : 1796.9 : Total : ---- : 201.22 : 1587.7							
Period III							
Silage : 3060.0 : 21.07 : 598.30 : Silage : 2940.0 : 19.99 : 567.42 Grain : 700.0 : 79.10 : 517.94 : Grain : 740.0 : 88.14 : 577.52 Hay : : : : Hay : : : (alf.) : <u>860.0</u> : <u>86.24</u> : <u>429.56</u> : (soy) : <u>960.0</u> : <u>67.96</u> : <u>451.10</u> Total : ---- : 186.41 : 1545.7 : Total : ---- : 176.09 : 1596.0							

*DCP - Digestible Crude Protein.

**TDN - Total Digestible Nutrients.

Table V. -- Average Per Cent Composition of Feeds

Feed	Moisture	Acidity	Ash	Crude tein	Fiber	NFE*	Fat
Period I							
Grain Mixture	10.84	----	4.98	14.19	4.69	60.91	4.39
Silage (sorgo)	69.59	2.66	1.69	1.41	7.94	16.41	0.75
Soy bean hay	8.56	----	8.49	9.63	33.59	38.51	1.22
Alfalfa hay	8.53	----	9.48	14.71	33.75	32.14	1.41
Period II							
Grain mixture	11.05	----	5.65	14.75	5.10	59.29	4.16
Silage (sorgo)	66.92	1.77	2.06	1.43	8.69	18.49	0.64
Soy bean hay	17.73	----	8.14	9.43	30.77	32.83	1.10
Alfalfa hay	10.83	----	5.78	13.14	35.27	33.25	1.75
Period III							
Grain mixture	11.13	----	5.49	14.13	4.50	60.42	4.33
Silage (sorgo)	69.02	2.21	1.83	1.34	7.64	17.25	0.71
Soy bean hay	14.75	----	9.88	9.71	33.94	33.67	1.05
Alfalfa hay	11.29	----	7.75	14.14	32.73	32.70	1.39

*NFE - Nitrogen Free Extract.

Table VI. -- Average Per Cent Digestibility of Feeds Used.

(Taken from Henry and Morrison, 1923, Appendix II.)

Feed					
	Carbohydrates				
	Crude				
Dry matter	protein	Fiber	NFE**	Fat	
Grain mixture*	81.3	77.3	49.6	85.4	85.3
Silage (sorgo)	66.0	51.0	65.0	71.0	82.0
Soy bean hay	60.0	73.0	57.0	64.0	44.0
Alfalfa hay	60.0	71.0	43.0	72.0	38.0

**NFE - Nitrogen Free Extract.

* Calculated by taking four times the coefficient of digestibility of corn plus two times the coefficient of digestibility of bran plus the coefficient of digestibility of linseed oil meal divided by seven. (Taken from Henry and Morrison, 1923, Appendix II.)

Table VII. -- Per Cent Digestible Nutrients in Feeds.

Feed	Total dry matter	Crude protein	Carbohydrates	Fat	Total
<u>Period I</u>					
Grain Mixture	89.16	10.92	54.07	3.73	73.28
Silage	30.31	0.71	15.30	0.42	16.95
Soy bean hay	91.44	7.02	59.72	0.53	47.93
Alfalfa hay	91.47	10.44	37.64	0.53	49.27
<u>Period II</u>					
Grain mixture	88.95	11.35	52.88	3.53	72.17
Silage	33.08	0.72	16.87	0.35	18.37
Soy bean hay	82.27	6.88	38.54	0.48	46.50
Alfalfa hay	89.13	9.52	39.10	0.67	49.92
<u>Period III</u>					
Grain mixture	88.87	10.88	53.55	3.68	72.71
Silage	30.98	0.68	15.43	0.39	16.98
Soy bean hay	85.25	7.08	40.88	0.46	48.99
Alfalfa hay	88.71	10.03	37.61	0.52	48.81

Table VIII. -- Average Per Cent Digestible Nutrients
in Feeds Used.

Feed	Total	dry	Crude	matter	protein	Carbohydrates	Fat	Total
Grain mixture	88.99	11.05				53.50	5.64	72.72
Silage	31.78	0.70				15.87	0.39	17.47
Soy bean hay	86.32	6.99				39.71	0.49	47.81
Alfalfa hay	89.77	9.93				38.12	0.57	49.33

Table IX. -- Weights and Production of Individual Cows

Group I	Period I (alfalfa)			Period II (soy bean)			Period III (alfalfa)		
	Milk	Fat	Body weight	Milk	Fat	Body weight	Milk	Fat	Body weight
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
151	740.0	25.38	1357.0	551.8	19.25	1357.0	427.8	14.71	1344.0
257	393.7	16.96	1235.0	512.4	15.90	1234.0	239.8	9.99	1227.0
276	600.6	25.70	957.0	496.1	21.58	975.0	456.5	19.17	964.0
427	320.9	15.24	976.0	275.9	13.90	987.0	258.0	12.04	987.0
291	499.7	19.53	906.0	407.8	16.39	917.0	416.4	15.32	907.0
Total	2554.9	102.66	5429.0	2044.0	85.02	5470.0	1793.5	71.23	5429.0

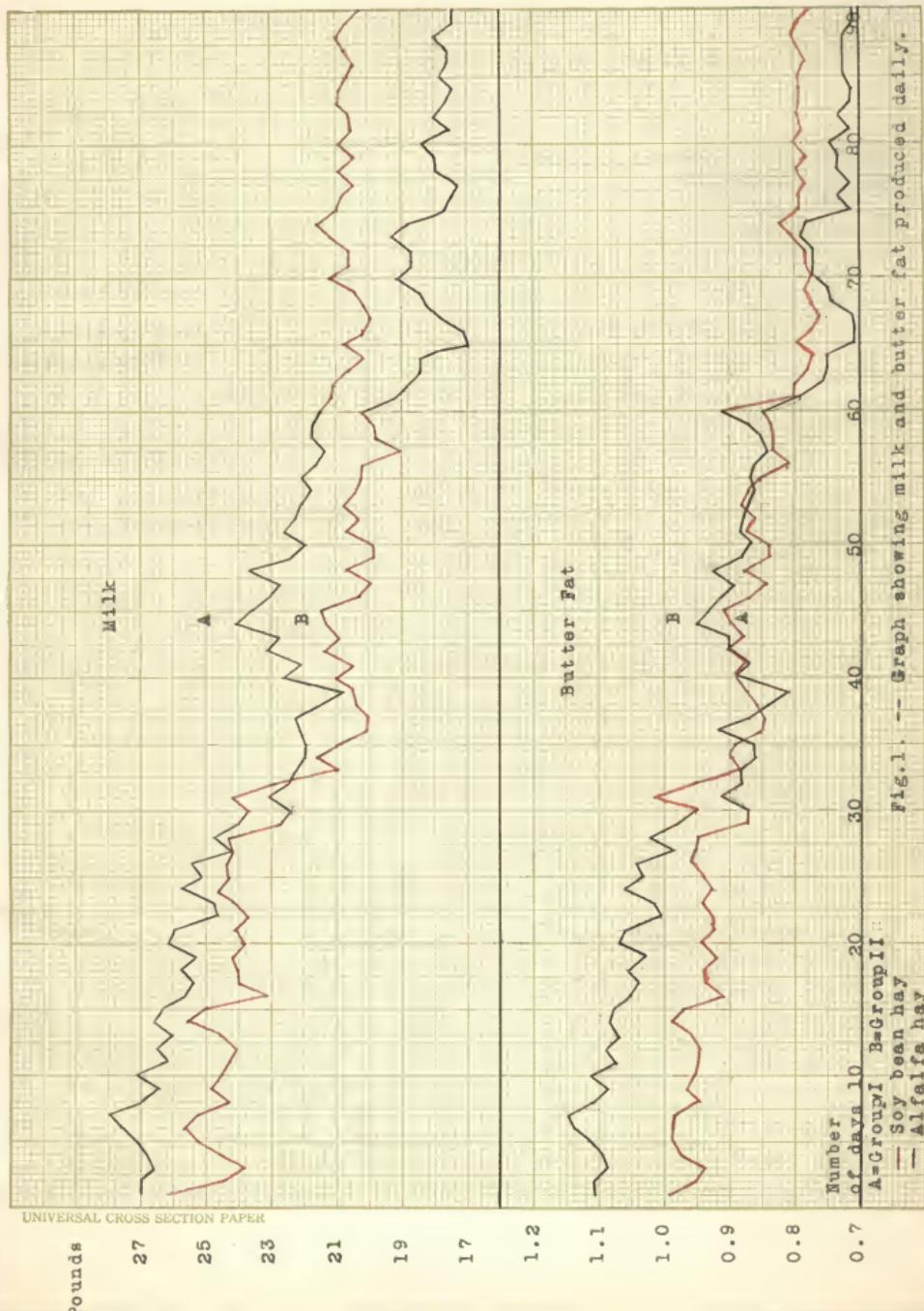
Group II	(soy bean)		(alfalfa)		(soy bean)	
	1	2	1	2	1	2
179	454.0	14.80	1066.0	421.6	14.35	1067.0
287	556.1	20.57	1056.0	522.4	19.06	1045.0
284	458.6	16.55	1035.0	400.4	15.37	1008.0
446	404.2	20.21	820.0	374.5	19.92	819.0
272	590.0	21.53	1041.0	545.3	19.50	1041.0
Total	2442.9	93.46	5018.0	2262.2	88.18	4980.0
					2106.2	78.15
						5008.0

Table X. -- Summary of Feeds, Digestible Nutrients, Production, and Body Weights.

			Diges-	Total di-				
			tible	gestible				
			orude	protein:nutrients	Milk	Fat	Fat	Body Weight
	Silage	Grain	Hay	:	:	:	:	:
Group I								
Av. Periods:			Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
I and III (alfalfa)	3010.0	770.0	980.0	205.33	1655.91	2176.7	86.94	4.08
Period II (soy bean)	2500.0	860.0	1240.0	204.79	1599.48	2044.0	85.02	4.27
Difference	510.0	90.0	260.0	0.54	56.43	132.7	1.96	0.19
								41.0
Group II								
Av. Periods:								
I and III (soy bean)	2470.0	780.0	1130.0	184.99	1626.95	2274.5	85.82	3.85
Period II (alfalfa)	2620.0	760.0	980.0	175.96	1466.00	2262.2	86.18	3.96
Difference	150.0	20.0	150.0	9.03	160.95	12.3	2.36	0.11
								34.0

Table XI. -- Pounds Nutrients Required to Produce
100 Pounds of Milk and a Pound of Butter Fat.

	When Alfalfa hay was fed	When Soy bean hay was fed	Efficiency of soy bean compared to alfalfa hay
<hr/>			
Group I			
<hr/>			
	<u>Pounds</u>	<u>Pounds</u>	<u>Per cent</u>
Protein per 100 pounds milk..:	9.43	10.01	94.20
Total digestible nutrients : per 100 pounds milk.....:	76.74	78.25	98.07
Protein per pound butter fat.: Total digestible nutrients : per pound butter fat.....:	2.35	2.40	97.91
	18.98	18.81	101.04
<hr/>			
Group II			
<hr/>			
	:	:	:
Protein per 100 pounds milk..:	7.77	8.13	95.56
Total digestible nutrients : per 100 pounds milk.....:	64.83	71.53	90.63
Protein per pound butter fat.: Total digestible nutrients : per pound butter fat.....:	1.99	2.15	92.55
	16.64	18.95	87.81
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